Analysis of European Topographic Maps for Monitoring Settlement Development

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Abstract. In this study we analyze and evaluate analogue large-scale European topographic maps with regard to their suitability for automated acquisition of urban land use information. Land use change detection using historic geographic information is still widely limited to local case studies. Efforts to build national (e.g., NSDI), continental (e.g., INSPIRE, SEIS) or even global (e.g., GMESS, GEOSS) databases on land use and its change require harmonized and objective spatial information with nationwide coverage. Topographic maps have proven an important data source for deriving this information. In order to assess the possibilities for acquiring land use information, we investigated the potential of topographic maps on a scale between 1:25,000 and 1:50,000 of 19 European national mapping agencies. The evaluation criteria comprise projection metadata for operational geo-referencing, information about the areal and temporal coverage of a map series and its degree of revision for map interpretation. The representation of urban land cover objects such as buildings, urban blocks and transport infrastructure, in both dense urban and sparsely settled rural regions, is the focus of the map design analysis (e.g., attributes of filling, line symbols and layer scheme). The results will be used to enhance image interpretation algorithms for the retrieval of spatiotemporal information on a transnational basis in Europe.

Keywords: European topographic maps, map analysis, land use change

1. Introduction

Recent and past land cover and land use information are of great importance for both urban and landscape research (e.g., Kienast 1993; Neubert & Walz, 2002; Witschas, 2003; Podobnikar & Kokalj, 2006; Perret et al. 2009). However, land use change detection using historic geographic information is still widely limited to local case studies. Long-term studies

and national, continental and global databases on land use change require harmonized and objective spatial information with a large areal and temporal coverage. Topographic map series have proven an important and low cost data source for deriving this information automatically, e.g., Leyk et al. (2006), Chiang & Knoblock (2009), Meinel et al. (2009), Pezeshk & Tutwiler (2011), and Herold et al. (2012). However, map design and representation of cartographic content affect the performance of the cartographic pattern recognition algorithms and, consequently, restrict comparability of the extracted information.

A previous comparative study by Kent & Vujakovic (2009) revealed a great stylistic diversity in European 1.50,000 topographic maps. Furthermore, generalization effects in secondary scale maps such as displacement and simplification influence the quality of the extracted thematic and spatial information.

The aim of this study is to investigate the map style in the context of automated map image analysis particularly for the acquisition of urban land use information. Thus, the focus is mainly set to the cartographic representation of urban land cover objects such as buildings, urban blocks and transport infrastructure, in both dense urban and sparsely populated rural regions. In order to assess the temporal coverage, the creation and availability of the first available topographic map series of each country is investigated.

2. Inventory

European topographic maps from 19 national mapping agencies on a scale 1:25,000 and 1:50,000 could be included in this study. Topographic maps of the following countries have been available: at scale 1:20,000 to 25,000 Belgium, Denmark, Estonia, France, Great Britain, Italy, Croatia, Luxembourg, the Netherlands, Poland, Switzerland, Spain, Czech Republic, and Hungary and at scale 1:50,000 Ireland, Latvia, Lithuania, Norway, and Sweden. For the following nations the first available map series could be analyzed: Finland, Greece, Austria, Portugal, and Slovakia (see Figure 1).

For each national topographic map series representative map sheets portraying low and densely populated regions of each nation's capital region have been chosen.

A comprehensive metadata database has been build for all map series, including bibliographic and updating information, language(s) of the map key, and geodetic information such as reference system, ellipsoid, map grid. The latter is of interest not only for automated georeferencing methods but

Figure 1. Overview of the maps included in this study.

also for a geometric harmonization of the extracted information (transformation and integration into a uniform data schema). In the following, the evaluation methodology and criteria are briefly described.

3. Methods

For the acquisition of large scale urban land use information from maps, certain requirements have to be fulfilled: complete coverage, regular update cycles, detailed and complete representation of built-up areas, preferably at building level including use such as residential, commercial, etc. Based on these requirements a criteria matrix has been set up for evaluation.

The evaluation criteria comprise object representation (e.g., single building representation, parcel boundaries), coloring, layer structure (distinct content separation for image analysis), type and form of lettering (merging), and the form of map grid.

The analysis is based on the map key and representative subsets of the map sheets. The map symbols are categorized into a generic land use scheme: built-up, transportation, water bodies and open space. The analysis of the map content comprises point (discrete), linear and areal (continuous) map symbols such as various types of buildings and transport infrastructure. The texture of the symbols is categorized in gridded, geometric and iconic.

The color layers (CMYK, special and mixed colors) are described according to the map key. It is marked if different land uses share the same layer. This is of particular interest for automated image analysis such as color image segmentation.

4. Results and Discussion

There is a wide dissimilarity between official topographic cartography of similar metric scale in Europe. These differences in map design and land use representation challenge cartographic pattern recognition in many ways and restrict comparableness. Generalization effects in secondary scale maps such as displacement and simplification influence the quality of the extracted thematic and spatial information. Furthermore, most national mapping agencies in Europe still use national reference systems as graticules in topographic maps while depicting the international UTM (Universal Transverse Mercator) grid coordinates.

Future research will include further European maps, further evaluation criteria, and first tests of automated land use information extraction.

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